CHAPTER 5
SURVEY DATUM POINTS

5-1. Permanent datum points.

a. The establishment of reliable permanent (10 years) datum points for survey measurements in seasonal frost and permafrost areas often requires substantial effort and care[19]. In northern areas, conventional types of benchmarks, satisfactory in warm climates, are subject to frost heave and/or thaw settlement which may produce many inches of seasonal movement, often progressive. Trees, boulders and even foundations of structures may move seasonally. Even benchmarks placed in bedrock cannot necessarily be relied on as rock often contains mud seams which can produce frost heave and ice layers which will cause settlement on thaw. The problem of frost heave is most difficult in those northern areas that have very deep annual frost penetration because it is necessary to support the datum points at very substantial depths in the ground to assure stability; also the magnitudes of frost heave forces in these areas are potentially very large.

b. Movements can result not only from simple frost heave but also from the soil volume changes attending the horizontal and vertical moisture movements which accompany frost action, from the expansion and contraction caused by the annual variation of temperatures within freezing or frozen soil and from solifluction and other types of downslope movement. Moisture movements during freezing may actually cause lowering of surfaces of some soils. The effects of contraction and expansion are not simply lateral; because temperature gradients with depth cause differential dimensional changes, bending tends to occur with complex combinations of vertical and horizontal movement.

c. Permafrost areas containing patterned ground and ice wedges should be assumed especially unfavorable. Areas showing evidences of solifluction or slope movement should be avoided whenever possible. If datum points must be placed in such areas they should be tied in to more stable points and rechecked often enough so that movements with time can be known.

d. Care should be taken to locate benchmarks away from potential thawing influences such as buildings, roads and streams.

e. In order to establish a reliable datum point in a seasonal frost or permafrost area firm support must be provided in stable material below the annual frost zone and the supporting rod must be isolated from the effects of frost action where it passes through the annual frost zone. As shown in figure 5-1, this isolation can be provided by an outer casing, with the space between the rod and casing filled with a viscous substance which has very low relative shear strength at all temperatures yet is solid enough at summer temperatures to keep water and soil from entering and accumulating in the annular space. For a permanent datum point, this space should extend at least 1 to 3 feet below the predicted annual frost zone depth after construction, depending on the estimate confidence, to make sure that no frost heave forces can act on the datum rod. The rod should extend sufficient additional distance below this point so that the rod will be stably supported, taking into account the sometimes substantial length of unsupported rod within the casing. For relatively shallow annual frost zones the rodembedment should be at least 5 feet; for longer unsupported lengths it should be more.

f. Permanent datum points in deep seasonal frost or borderline permafrost areas should desirably employ a standard weight pipe of minimum 2 inch nominal diameter for the datum point rod because of the relatively long unsupported length through the deep layer of seasonal freezing. The outer casing should be large enough to allow at least 1 inch of space between the datum rod and the casing, for effective placement of oil, wax, or other substances and for positive clearance. Before placement of the viscous material the space between the datum rod and the outer casing should be carefully checked to make sure that the space is free of soil over 100 percent of the length of the outer casing, that there is no water at the bottom and that the rod and casing are not in contact with each other. Otherwise, a plug of ice or frozen soil or friction might transmit drag from the outer casing to the datum rod. The top surface of the vicous material may be given additional protection against water or soil infiltration by a suitable light cover of fabric, plywood or metal.

g. It is recommended that a standard floor flange or welded flat plate be fitted to the bottom of the rod, the datum point hole being drilled large enough to permit this. This will help to stabilize the rod against movement even if skin friction on the embedded portion of the rod should prove inadequate. Other types of projections can be fitted to the length of rod below the casing for the same purposes. Holes or slots are also sometimes cut in pipe-type datum point rods into which slurry will penetrate, helping to increase holding power. The casing should also have an external flange at its lower end to control the tendency for the casing to be jacked progressively out of the ground by frost heaving. For a permanent benchmark, this flange should be designed to develop and withstand full passive forces equal to the

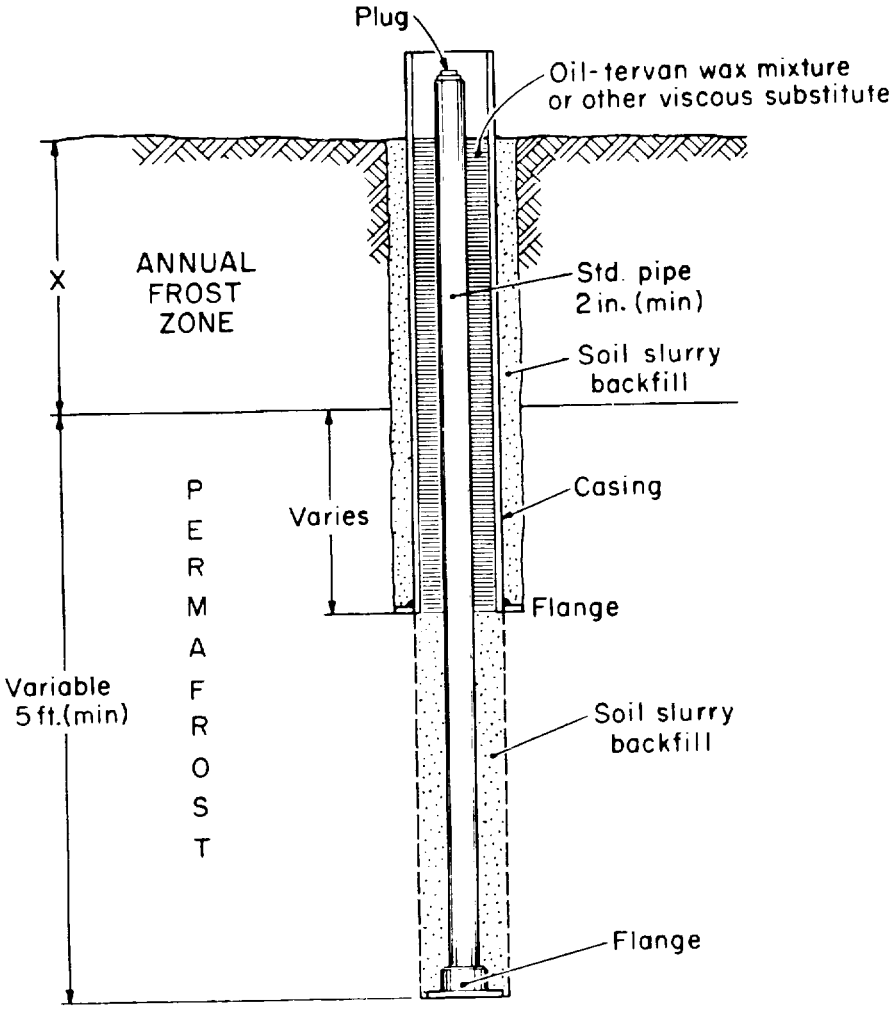

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Figure 5-1. Recommended permanent benchmark[39].

maximum frost heave force which can be developed on the casing.

h. For permanent type datum points requiring very high precision, the casing and viscous backfill should extend to a depth below which the annual temperature variation is 2 °F or less, usually about 30 feet in northern areas. For extreme precision, a special study of requirements for attaining needed stability may be required. Black[126] has suggested that in areas such as the northern part of Alaska the datum point may have to be supported at as deep as 65 feet (20 m) to obtain high stability.

i. The natural thermal regime and the method of placing a datum point are important factors in datum point performance. In permafrost areas, casing anchorage and datum rod stability depend on achieving rapid and thorough refreezing during installation and maintaining this during the life of the datum point. Disturbance of the thermal regime may interfere with this, particularly in marginal permafrost areas.

j. Dry augering or refrigerated fluid mechanical drilling create the least disturbance of frozen soil and permit much more rapid freezeback of the backfill material than steam thawing or drilling methods using warm fluids. This is of utmost importance in the more southerly areas where permafrost is near the thawing point (32 °F). Mechanical drilling may be the only practical method where bouldery soils or bedrock are involved. On the other hand, test pit installation, though very laborious, may sometimes be found the most practical approach in remote areas inaccessible for suitable drilling equipment. In all permafrost areas, freezeback of slurried-in datum points can usually be expected to be complete in not over two weeks, often, much less, provided dry or refrigerated-fluid drilling methods are used, the annular space is not over 1 1/2 to 3 inches and the slurry temperature when placed is not more than a few degrees above 32 °F, except that in marginal permafrost areas this applies only during the period of February to early June, when temperatures in the upper permafrost are depressed. Refreezing times for slurries can be estimated using the procedures outlined in paragraph 4-8d. Because refreezing does not always occur at a uniform rate around the embedded rod or pipe, some bending or small displacement may occur during this process. Therefore, the datum point should not be used as a reference point until refreeze is complete.

k. The viscous substance placed in the annular space between the casing and the benchmark rod may be a heavy grease, a special oil-wax mixture such as 70 percent Mentor 29 oil with 30 percent Amber Tervan wax or Socony Mobil Cerise AA by weight, or other viscous material or mixture which will be firm enough at normal summer temperatures to support gravel or sand particles on the surface yet transmit negligible frost heave forces to the datum rod in winter. If oil-wax mixture is used, the oil and wax should be heated separately to about 200°F, then mixed. The mixture then may be poured into the annular space while it is still warm enough for easy placement.

5-2. Temporary datum points.

a. Since these need to be stable only for limited periods of time, less elaborate precautions are required than for permanent installations. However, even though shorter times are involved, stability requirements may be just as stringent. Thus, a stable temporary benchmark must be solidly anchored in stable ground and must be isolated from the effects of seasonal frost heave or thaw-settlement forces during its period of use, in accordance with the same principles as for permanent benchmarks. However, it may be feasible to use a smaller flange or no flange on the casing. For example, an unflanged casing embedded 2 ft below the annual frost zone and which may heave 8 in./yr can be expected to protect the benchmark from heave for at least 3 years.

b. For construction projects of limited duration it may suffice to install a temporary benchmark by hand augering or test pitting to below the depth of seasonal frost and then driving a relatively small diameter rod into the underlying material for sufficient depth to obtain stable embedment, placing an unflanged casing around the rod, backfilling on the outside with soil and placing the oil-wax or other mixture in the annular space. Small diameter pilot auger holes may be employed to facilitate driving. Hand-sledge driving is of limited effectiveness; a heavy weight (up to about 350 lb) operated with a tripod and winch will extend effectiveness. Driving should be assumed impractical in other than in warm (above 25 F), fine-grained frozen soils. Freezeback of datum points driven into permafrost may be assumed almost instantaneous because of the relatively small amount of heat to be dissipated. Often these operations may be carried out easily after the end of the summer thaw (though ground water may cause problems). Even if the casing is frost heaved several inches in winter the point may remain stable long enough to get the job completed.

c. On the other hand, when extended post construction performance feedback measurements on the structure are to be made, one or more permanent type datum reference points should be installed.